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July 28, 2015

VIA ELECTRONIC FILING

Marlene H. Dortch, Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, D.C. 20228

Re: IB Docket No. 13-213, RM-11685

Dear Ms. Dortch,

On July 27th, 2015, I met with Bruce Romano, Patrick Forster, Chad Beattie, Rashmi Doshi, and William Hurst of the Office of Engineering and Technology (OET); and Chip Fleming and Jose Albuquerque of the International Bureau. Also in attendance was Sitarama Penumetsa, Director of Product Management at Ixia. The meeting was conducted via an FCC-hosted WebEx web conference.

I presented the attached slides covering four important technical issues that remain unresolved in this proceeding:

1. **Globalstar has provided no quantitative technical response to tests showing TLPS interference with Bluetooth Low Energy Hearing Aids, nor have they produced quantitative results addressing interference with other Bluetooth devices.**

Slide 3 summarizes the fact that a simple test quantitatively shows TLPS doubled the packet error rate for Hearing Aids using Bluetooth Low Energy. Globalstar has failed to provide any quantitative tests of their own, relying exclusively on qualitative opinions from non-hearing-impaired adults. As stated by the CTO of Etymotic Research, “Assessing the psychoacoustic impact of interference is a specialized topic. The impact of interference on people with normal hearing is different from that on people with hearing loss....The potential impact for children with hearing loss is different from that of adults.”¹

Globalstar’s written response to this specific test states “Any negative effect from TLPS could only be detected with special purpose measurement equipment”.² The so-called “special purpose measurement equipment” simply collected statistics providing an unambiguous measure of relative interference levels, independent of the opinion of any given listener. To assess the risk posed by TLPS to devices used by hearing-impaired children and adults, does Globalstar and their paid consultant, Roberson & Associates, truly believe the Commission should rely exclusively on the perception of non-hearing-impaired adults who lack experience in testing techniques needed to evaluate the effect of interference on speech intelligibility?

It is important to note that Globalstar cited a quote from a Starkey technical paper implying hearing aids could not operate using Bluetooth Low Energy³. However, the next section of that same paper explains “Halo hearing aids feature a new wireless protocol developed by Apple that provides a robust low-power data and audio connection between a patient’s hearing aids and iPhone.”⁴ It seems likely this Apple protocol is based on their patent titled “Audio transfer using the Bluetooth Low Energy standard”, filed

¹ See Letter from Mead C. Killion, CTO and Founder, Etymotic Research, Inc. to Marlene H. Dortch, Secretary, IB Docket 13-212 (July 19, 2015), Page 2.

² See Attachment to Letter from Barbee Ponder to Marlene H. Dortch, Secretary, IB Docket 13-212 (March 27, 2015), “Review of Bluetooth SIG Ex Parte Filing of March 20, 2015 Titled..”, Page 4.

³ Jason Galster, “Wireless Technology is Constantly Changing – Are you keeping up?”, Starkey Hearing Technologies, https://starkeypro.com/pdfs/technical-papers/Wireless_Technology_is_Constantly_Changing_White_Paper.pdf, Page 3.

⁴ Ibid.

⁵ See <http://www.google.com/patents/US8849202>

on February 23, 2012 and granted on September 30, 2014. Furthermore, the final section of the article below provides an indication of where the hearing aid industry is going.⁶



Loud and Clear

Phones

Cars

Handsfree Calling

Drive Smart, Drive Safe

Consumer Electronics

Loud and Clear

by Karen D. Schwartz



Hear that? It's the sound of a technological revolution for the hearing impaired. Bluetooth® wireless technology turns hearing aids into headsets for phones, MP3 players and more.

Low Energy Technology Advantage

Although it's clear that Bluetooth technology can help transform the hearing aid industry, more must be done before the hearing-impaired population can experience wide-scale benefits.

Power requirements present a challenge. Hearing aids must do a lot with a limited amount of battery drain while performing complex tasks such as real-time noise reduction, directional sound identification, automatic feedback cancellation and customized frequency amplification. Classic Bluetooth technology simply requires too much battery power to fully integrate with what the hearing aid must do, notes Dr. Paul Dybala, president and editor of audiologyonline.com, an information resource for the hearing impaired.

In most cases today, an external gateway device (such as the Oticon Streamer or Phonak's SmartLink+) uses a low-power wireless protocol to talk to the hearing aid. The gateway device then uses Bluetooth wireless technology to connect with other devices, such as cell phones. Because these gateway devices are relatively large – the Oticon Streamer, for example, is approximately the size of a typical MP3 player – they can have larger batteries. But that has to change if Bluetooth technology is going to revolutionize hearing aids.

"The key is getting the power requirements low enough so you can fit all of the technology into the hearing aid itself," Dybala says. "Bluetooth seems to be the wireless standard that will unite all of this. The low-power requirements of hearing aids eventually will be met and hearing aids will be able to take advantage of the universality of Bluetooth to help people communicate more effectively through audio devices."

The advent of Bluetooth low energy technology, the hallmark feature of the Bluetooth Core Specification Version 4.0, answers the challenge of battery drain. And, given the rate at which technology advances, it may not be long before a Bluetooth wireless radio inside a hearing aid will eliminate the need for additional accessories. It will also allow direct communication between computers and certain types of programmable hearing aids.

The rapidly evolving set of Bluetooth Low Energy applications and devices is a perfect example of why TLPS approval could have the opposite effect of inducing "increased investment and innovation throughout the industry and ultimately improve competition and consumer choice", as expressed in the NPRM (see Slide 29). Increased interference from TLPS on Bluetooth Low Energy-based devices has the potential to impede investment in this area, and by extension, reduce consumer choice.

2. Controlled testing shows increased Wi-Fi channel 11 interference due to TLPS.

Extensive studies have been published on the effects of adjacent "non-overlapping" Wi-Fi channels spaced 25MHz apart. In contrast, no controlled, quantitative studies have been published for Wi-Fi channels spaced 22MHz apart, as are Wi-Fi Channels 11 and 14 (the proposed TLPS channel). The analysis and test results presented in Slides 6-15 clearly demonstrate increased interference on Channel 11 due to the 22MHz channel spacing (vs 25MHz). These preliminary results indicate the need for further controlled

⁶ <http://www.bluetooth.com/Pages/Loud-and-Clear.aspx>

testing in order for the Commission to sufficiently understand how much, and in what manner, TLPS will interfere with Wi-Fi.

We also discussed the importance of creating a precisely controllable environment for tests such as this, and the need for test equipment that provides simultaneous statistics at the physical, Wi-Fi media access control (MAC), and Network layers. In addition to previously identified problems with their demonstration environment, Globalstar's use of non-commercial, Network-layer-only test tools did not provide the necessary level of information to determine the impact of TLPS on Wi-Fi.

3. The fact that Globalstar found it necessary to remove the co-existence filters from the Ruckus Access Points used in the March demonstration raises multiple issues.

Slides 17-20 provide an analysis of publicly available information that refutes Globalstar's claim that all "consumers could use their existing Wi-Fi enabled devices...if restrictions in radiofrequency (RF) software in the current devices are lifted by modifying their devices' software." Data from the OET's emissions report, the commercial Ruckus 7982's Part 15.247 compliance report, and a variety of Part 15.247 reports for popular consumer client devices provide evidence that a material percentage of access points and consumer device hardware would require modification to enable TLPS operation.

Responses to the NPRM on slides 28 and 32 describe why this fact has implications not only for the impact on all LTE-enabled Wi-Fi client devices, but raises complex issues when it comes to equipment certification. For instance, if devices with co-existence filters enabled for TLPS with only a software change, the Commission is faced with the possibility that an unpredictable percentage of owners will see material degradation in their TLPS performance, even on makes/models which have passed compliance tests. The level of impairment will vary from device to device (due to unavoidable manufacturing variability in the co-existence filters), as well as hour-to-hour for a single device (due to "temperature motion" of the co-existence filter). The important point to understand is that most co-existence filters begin attenuating the RF signal somewhere well within the TLPS frequency band, and the extent of TLPS impairment will vary materially due to a combination of manufacturing variability and "temperature motion".

4. The reduced power level used in Globalstar's March demonstration presented ~6dB lower interference to Wi-Fi channel 11 than would have been the case had the access point been set to maximum power, as it would in many real-world scenarios.

Slides 22-26 provide an analysis of data from the OET's emissions report⁷ illustrating another reason the March demonstration did not provide a realistic indication of the negative impact TLPS will have on Wi-Fi Channel 11, Bluetooth, and Bluetooth Low Energy. Due to the limited space, Globalstar understandably configured the modified Ruckus Access Points to operate at 3dB below the maximum transmit power level. However, by doing so, Globalstar effectively reduced the adjacent channel interference by ~6dB relative to what it would have been were the AP's configured at maximum power. To present a "real-world" environment, reflective of the common scenario where hardware would be configured at maximum transmit levels, Globalstar should have set the access points to maximum power, and used 3dB attenuators at each of the antenna ports. The effective radiated power in the TAC would have been identical, but the adjacent channel interference level "seen" by any clients and access points operating on Wi-Fi Channel 11 would have been an average of ~6dB higher.

The ~6dB difference in adjacent interference level ties back into the test results presented on slide 14. As the table shows, a difference of 6dB can, and likely will, have a dramatic impact on packet error rates seen on Wi-Fi channel 11.

The final section of the attached (slides 28-38) are responses to sections of the NPRM that are relevant to the technical material covered above.

Based on information available, I believe the Commission should terminate this proceeding now. If the Commission requires further analysis and/or test data before making a decision, I believe the Commission should publish updated guidance allowing interested parties to efficiently focus their efforts on providing such information.

⁷ See report TR 15-1002, "ELECTROMAGNETIC EMISSIONS CHARACTERIZATION OF SAMPLES USED AT TLPS DEMONSTRATION", prepared by the FCC OET (May 7, 2015)

Pursuant to Section 1.1206(b)(2) of the Commission's rules, an electronic copy of this letter and attachments are being filed for inclusion in the above-referenced dockets.

Respectfully Submitted,

Greg Gerst
Gerst Capital, LLC

cc: Ruth Milkman
David Strickland
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Chad Beattie
Rashmi Doshi
William Hurst
Troy Tanner
Jennifer Gilsenan
Karl Kensinger
Robert Nelson
Lynne Montgomery
Chip Fleming
Patrick Donovan
Stephen Buenzow

Open Technical Issues Regarding Globalstar's TLPs Proposal

Presented to Members of the:

International Bureau

Office of Engineering and Technology



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AGENDA

- 1) Globalstar has provided no quantitative technical response to tests showing TLPS interference with Bluetooth Low Energy Hearing Aids**
- 2) Controlled Testing Shows Increased Wi-Fi Ch.11 Interference from TLPS**
- 3) Co-existence Filter Removal from Ruckus AP Raises Red Flags**
 - FCC Report Language Implies Globalstar failed to inform FCC demo hardware was modified
 - Globalstar's prior claims that all Wi-Fi devices can be enabled for TLPS with a "firmware upgrade" are incorrect
- 4) Power level used in March Demonstration presented ~6dB lower interference to WiFi Ch. 11 than a Maximum Power real-world scenario**
- 5) Gerst Capital Response to NPRM**



TEST SHOWED BLUETOOTH LOW ENERGY ERRORS DOUBLED IN PRESENCE OF TLPS

The Bluetooth SIG Test Report quantitatively showed Bluetooth Low Energy Packet Error Rate doubled when TLPS was enabled¹

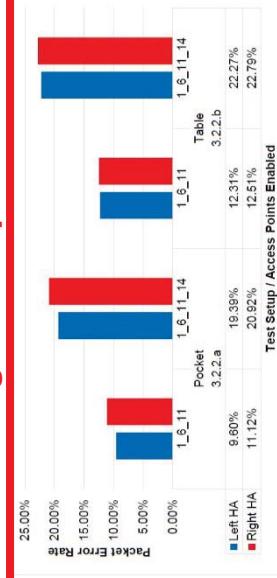
Simple, Repeatable Test Procedure

- a. One HA pair is worn on the ears of a human subject and an iPhone is placed in a pants pocket. An audio stream is initiated on the iPhone using the music player. The human subject walks about the room for 300 seconds while audio packet statistics are recorded by the iPhone. An Ellisys protocol analyzer [2] is simultaneously recording all Bluetooth traffic at this time. Upon completion, the audio packet statistics are downloaded from the iPhone and the Ellisys air trace is saved.
- b. One HA pair is worn on the ears of a human subject and an iPhone is placed on a table. An audio stream is initiated on the iPhone using the music player. The human subject walks about the room for 300 seconds while audio packet statistics are recorded by the iPhone. An Ellisys protocol analyzer [2] is simultaneously recording all Bluetooth traffic at this time. Upon completion, the audio packet statistics are downloaded from the iPhone and the Ellisys air trace is saved.

Quantitative Results Collected for a Key Performance Metric

Setup	HA Enabled Access Points	Total Samples	Missing Samples	Missed Packet Total	Total Packets Sent
3.2.2.a	Left 1_6_11	40144	614	4198	43728
3.2.2.a	Right 1_6_11	40147	752	4928	44323
3.2.2.a	Left 1_6_11_14	40150	1289	9348	48209
3.2.2.a	Right 1_6_11_14	40153	1610	10199	48742
3.2.2.b	Left 1_6_11	40143	980	5496	44659
3.2.2.b	Right 1_6_11	40143	808	5622	44957
3.2.2.b	Left 1_6_11_14	40147	2098	10901	48950
3.2.2.b	Right 1_6_11_14	40143	2232	11193	49104

Unambiguous Results Show Negative Impact of TLPS



Globalstar has not attempted to refute this test, relying solely on qualitative observations.

¹See Attachment to Letter from Mark Powell, Executive Director, Bluetooth SIG, Inc. filed to the FCC's IB Docket 13-213 (March 20, 2014) "TLPS and Bluetooth Demonstrations FCC Technology Center – March 6, 2012", Section 2.1.2 on Pages 4&5.



QUESTION FCC ASKED IN APRIL 14 MEETING REGARDING BLUETOOTH IN EUROPE

During April 14, 2015 Ex Parte meeting¹, an FCC staff member asked a question regarding Bluetooth operation in Europe where Wi-Fi Channels 12 & 13 are allowed

- Paraphrased Question: “If Bluetooth operates successfully in Europe, where Channels 12 & 13 are allowed, why would TLPS present a problem for Bluetooth in the US?”
 - Channels 12 & 13 overlap the “Free” Bluetooth Channels above Wi-Fi Channel 11, as does TLPS
- Key Point: TLPS Introduces a 4th Non-Overlapping Channel, whereas Europe’s 12/13 act as an alternative 3rd Non-Overlapping Channel for 11.

Possible Non-Overlapping Wi-Fi Channels (25MHz Spacing) in the US & Europe	"Free" Bluetooth Channels	"Free" vs. Current "Free" Bluetooth Channels in the US
1/6/11	22	
1/6/12	22	0%
1/6/13	23	5%
2/7/12	22	0%
2/7/13	23	5%
2/8/13	23	5%
3/8/13	23	5%
1/6/11/TLPS	16	-27%

¹See Attachment to Letter from Gerst Capital, LLC to Marlene H. Dortch, Secretary, FCC, IB Docket 13-213 (April 14, 2015) “Analysis of Globalstar’s TLPS Proposal”, Slides 4-10.



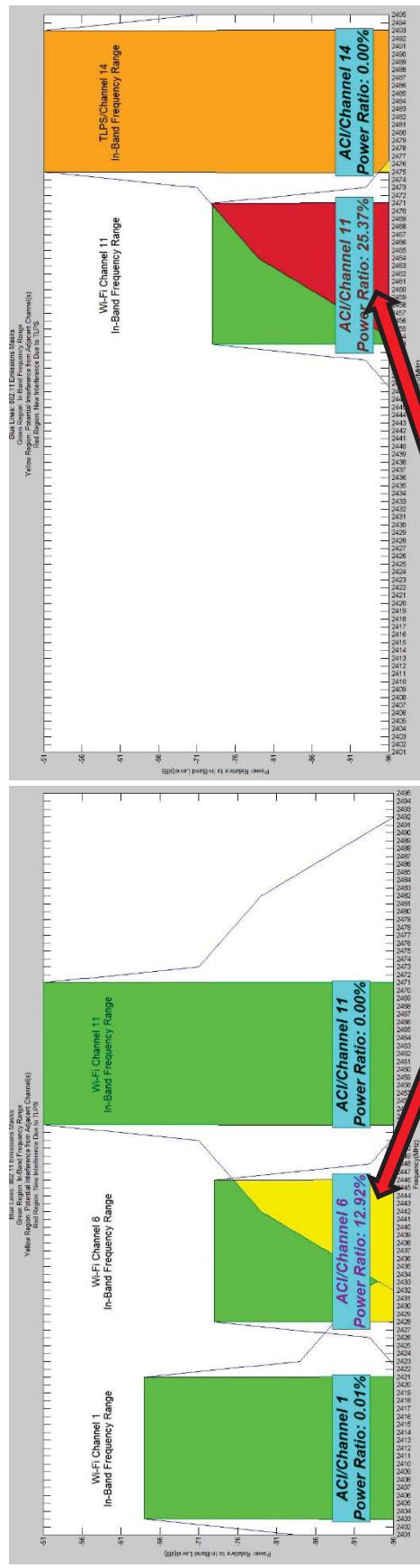
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 - Globalstar's prior claims that all Wi-Fi devices can be enabled for TLPS with a "firmware upgrade" are incorrect
- 4) Power level used in March Demonstration presented ~6dB lower interference to WiFi Ch. 11 than a Maximum Power real-world scenario
- 5) Gerst Capital Response to Nprm



ANALYTICAL VIEW: TLPS IMPACT ON Wi-Fi IN THE “REAL WORLD”

Using receive power levels seen on 8th Floor of FCC Building



**Narrower 22MHz Channel Spacing (Ch11<=>TLPS)
Doubles ACI/Desired Power Ratio (3dB increase)
vs. 25MHz Channel Spacing (Ch1<=>Ch6, Ch6<=>Ch11)**



WHAT HAPPENS IN A MIXED TLPS & NON-TLPS ENVIRONMENT?

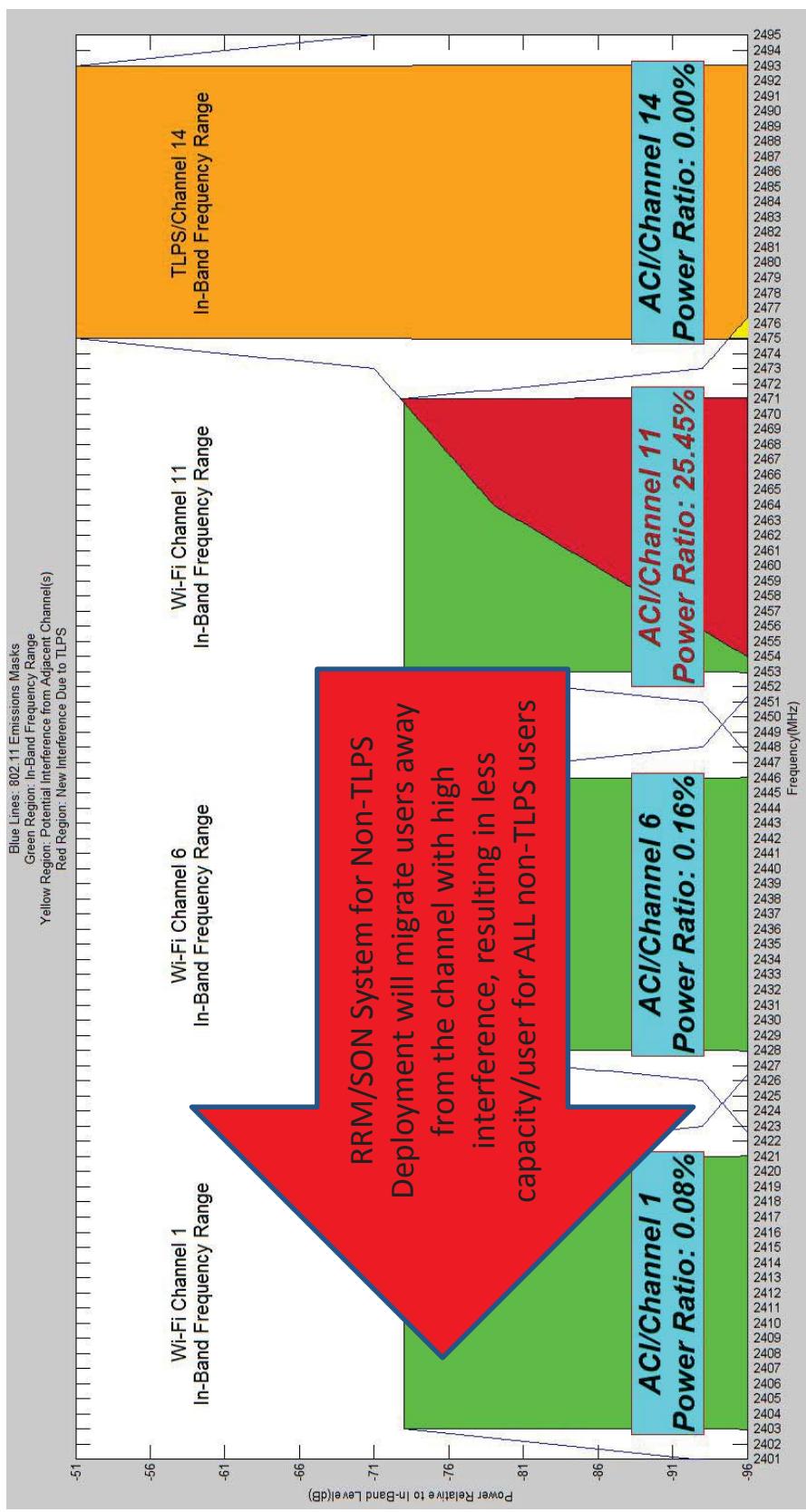
Due to increased ACI on Channel 11, the presence of a TLPS deployment will cause problems for non-TLPS networks using Radio Resource Management/Self Organizing Network systems (RRM/SON)

- RRM/SON systems continuously monitor, among other things, interference statistics across all APs in a network. If the RRM/SON system detects interference on a given channel, it can automatically move clients to a different AP and/or modify that AP's channel setting.
 - For Non-TLPS deployments, increased ACI on Channel 11 due to co-located TLPS devices is considered noise outside that network's control.
 - The net result is the TLPS deployment will negatively impact any co-located non-TLPS deployment by forcing more users onto Channels 1 & 6 than would otherwise be the case.
- ***In the scenario above, Wi-Fi users who fail to pay for Globalstar's TLPS service will suffer a DECREASE in service quality.***



WHAT HAPPENS IN A MIXED TLPS & NON-TLPS ENVIRONMENT?

For Non-TLPS Deployments with Automatic Radio Resource Management Software, the presence of TLPS will cause the system to “push” users from Channel 11 to Channels 1&6, resulting in more congestion on the lower two channels



**IMPORTANT DISCLOSURES REGARDING SLIDES TITLED “WI-FI
ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED
TLPS INTERFERENCE”:**

1. Ixia takes no position in the Globalstar TLPS Proceeding. Ixia provided test tools, expertise on how to use those tools, and supporting hardware. Gerst Capital specified and directed the execution of all tests. Ixia expresses no opinion on the test results, nor the conclusions drawn by Gerst Capital.
2. Ixia is willing to work with any interested party to design and conduct testing relevant to the TLPS proposal.
3. Neither Gerst Capital nor Ixia compensated the other for any aspect of this testing, including travel, equipment, or personnel. Neither party has an investment in the other, nor do the parties have any financial relationship.



WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE

Using Ixia's IxVeriWave¹ Platform, we conducted controlled testing to begin quantifying the impact of TLPS on Wi-Fi

Objectives

- Begin to quantify the impact of adjacent channel interference for 22MHz channel spacing (11<>TLPS) vs. 25MHz spacing (1<>6 and 6<>11)
- **Use IEEE 802.11-2012² “Adjacent Channel Rejection”³ (ACR) specifications as the guideline for test configuration**
- **Conduct “apples-to-apples” testing in a precisely controlled environment with simultaneous access to all statistics at the PHY, MAC, and Network layers.**

¹See Attachments to Letter from Gerst Capital, LLC to Marlene H. Dortch, Secretary, FCC, IB Docket 13-213 (May 19, 2015).

²See “Supporting Links” slide to download IEEE 802.11-2012 Specification. For 802.11n ACR specification, refer to section 20.3.21.2 on page 1745. For 802.11g, refer to section 19.5.3. on page 1647.

³IxVeriWave meets the more stringent “Alternate adjacent channel rejection” 802.11 specification in Table 18-14 on page 1612. The IEEE standard ACR specification is 16dB lower than the “Alternate” specification. Therefore, “consumer-grade” client devices (and likely most APs) will be MORE susceptible to ACI effects that what is shown in these tests. At the highest data rate, the “Alternate” limit assumes the interferer is 15dB higher than desired, while the standard limit assumes the interferer is 1dB LOWER than desired.



WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE

Test Scenarios

- **25MHz Channel Spacing:**
 - Configure Channel 6 as the “Desired” channel with the received power level constant across all tests
 - Configure Channel 11 as the adjacent channel “Interferer”
 - Record key “Desired” channel statistics as the adjacent channel “Interferer” power is increased.
 - Measure over “ACI level” (“Interferer” minus “Desired” power) range from 0% packet error rate (PER) to >50%
- **22MHz Channel Spacing:**
 - Without modifying testbed hardware, configure Channel 11 as “Desired” and TLPS/Channel 14 as “Interferer”
 - Using identical steps, record “Desired” channel statistics over the same “ACI level” range used in the 25MHz tests
- **20MHz Channel Spacing:**
 - Without modifying testbed hardware, configure Channel 6 as “Desired” and Channel 10 as “Interferer”
 - Using identical steps, record “Desired” channel statistics over the same “ACI level” range used in 25MHz tests

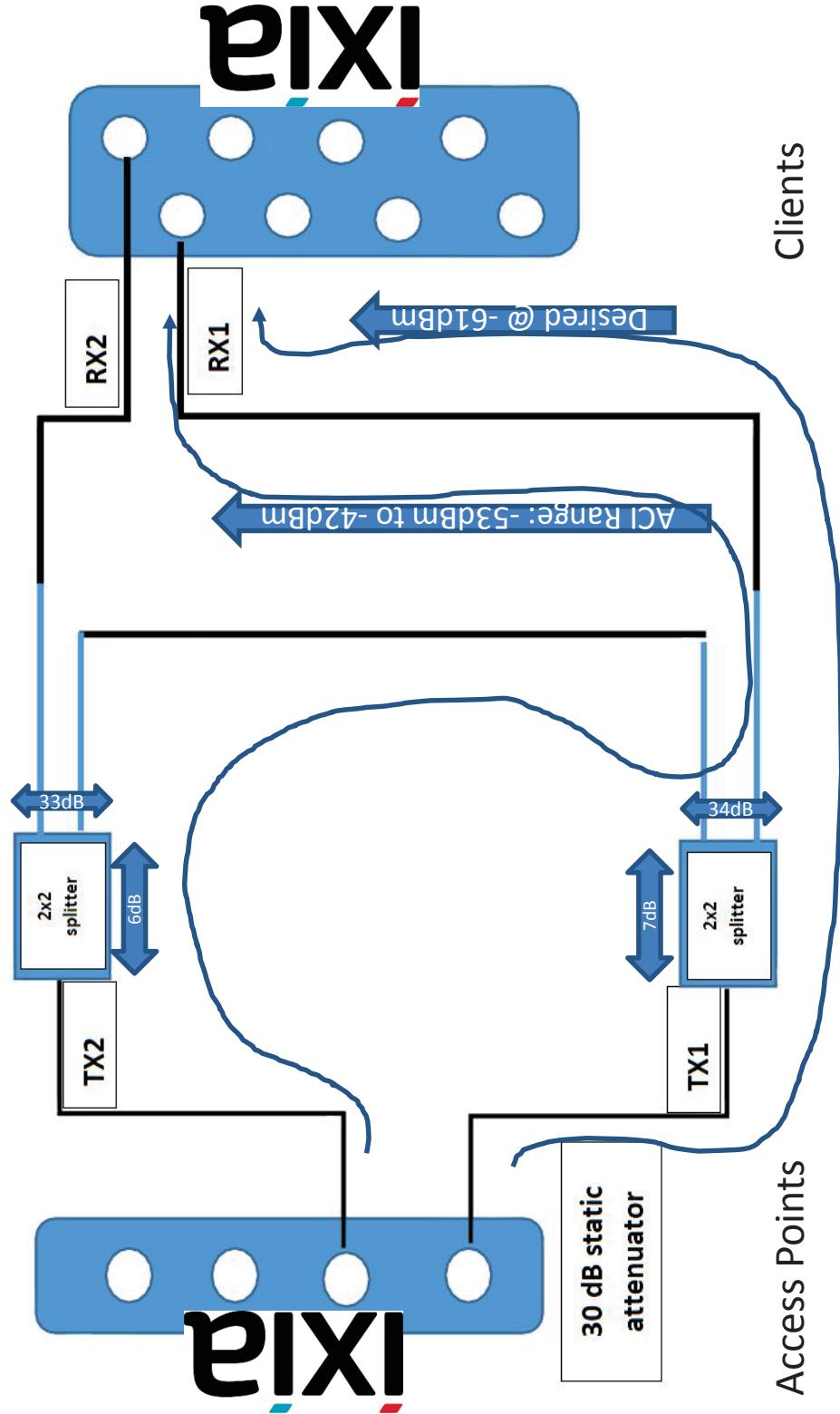


WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE

Testbed

Wi-Fi 802.11 a/b/g/n
WBW1104N

Wi-Fi 802.11 a/b/g/n/ac
RF36024



Results Summary and Implications:

Results show that, under precisely-controlled, identical conditions:

- 1) ACI-induced errors with 22MHz channel spacing is materially worse than 25MHz
 - At the “packet level”, 22MHz spacing is ~3dB worse than 25MHz spacing
 - “Packet level” results generally consistent with analysis showing ACI/Desired Power ratio of 22MHz vs 25MHz is ~2x (3dB) higher
- 2) **Severity of 22MHz packet errors is materially higher than 25MHz. Understanding the full system-level implications (i.e.: impact of different packet error types on different applications, different client hardware, etc.) requires more testing.**
 - 25MHz: PER driven by least severe FCS errors. ACI test range does not encounter most severe “Lost” packets, and “Malformed” packets remain under 5% for most of the ACI range
 - 22MHz: Minimal FCS errors because of earlier, more severe, sources of packet loss. Material “Lost” packets at upper ACI Levels, “Malformed” exceeds 5% for over 90% of the ACI range
 - 20MHz: FCS and “Malformed” errors remain minimal, with vast majority due to most severe “Lost” packets



WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE

Test Data for 25MHz Channel Spacing (Channel 6 Desired, Channel 11 Adjacent Channel Interferer)

Lowest Severity Error → Middle Severity Error → Highest Severity Error →

MSC Level	Desired Channel	ACI Level	Collected		Collected		Derived		Derived		Derived		Analytical					
			Desired Power at RX1 (dBm)	Power at RX1 (dBm)	Desired Channel Receive FCS Total Frame Rate	Desired Channel Receive FCS Total Frame Rate	Wireshark "%"	Malformed Frames"	Re-transmissions (= if(A>=3049, 1, 3049-A, A/[1/(C1-1) - 3.049, 0]))	Lost Frames (= if(A<=3049, 0, 3049-A, B+D+F))	FCS + Lost Frames (= if(A<=3049, 0, 3049-A, B/A))	"Traditional Malformed Packet Error Rate (= G/(A-D))	"True" Malformed Packet Error Rate (= [D+F]/[A+B])	% "Traditional Malformed Packet	Computed Potential	Computed Potential	ACI/Desired Power Ratio (%)	ACI/Desired Power Ratio (%)
7	6	11	-61	-53	8	3049	0	0.0%	-	0	0	0	0%	0%	0%	0.5%	-23	
7	6	11	-61	-52	9	3070	1	0.0%	-	21	0	1	0%	0%	0%	0.6%	-22	
7	6	11	-61	-51	10	3200	3	0.1%	3	151	0	6	0%	0%	0%	0.8%	-21	
7	6	11	-61	-50	11	3846	15	2.8%	111	797	0	126	3%	0%	3%	1.0%	-20	
7	6	11	-61	-49	12	4500	35	2.1%	97	1451	0	132	3%	1%	2%	1.2%	-19	
7	6	11	-61	-48	13	4900	150	1.3%	65	1851	0	215	4%	3%	1%	1.6%	-18	
7	6	11	-61	-47	14	4700	147	2.1%	101	1651	0	248	5%	3%	2%	2.0%	-17	
7	6	11	-61	-46	15	4500	550	3.2%	149	1451	0	699	15%	12%	3%	2.5%	-16	
7	6	11	-61	-45	16	4400	1500	4.9%	227	1351	0	1727	37%	34%	5%	3.1%	-15	
7	6	11	-61	-44	17	4300	1500	5.6%	255	1251	0	1755	39%	35%	6%	3.9%	-14	
7	6	11	-61	-43	18	4235	2880	6.8%	309	1186	0	3189	70%	68%	7%	4.9%	-13	
7	6	11	-61	-42	19	4200	3100	4.0%	175	1151	0	3275	75%	74%	4%	6.2%	-12	

Per IEEE Specification, the Adjacent Channel Rejection Limit is reached when the Packet Error Rate reaches 10%. At 25MHz spacing, the ACR limit is between 14-15dB.



WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE

Test Data for 22MHz Channel Spacing (Channel 11 Desired, TLPS/Channel 14 Adjacent Channel Interferer)

Lowest Severity Error → Middle Severity Error → Highest Severity Error →

MSC Level	Desired Channel	ACI Level	Collected		Collected		Derived		Derived		Derived		Analytical				
			Desired Power at RX1 (dBm)	ACI Power at RX1 (dBm)	Desired Channel Receive FCS Total Errored Frame Rate	Desired Channel Receive FCS Total Errored Frame Rate	Wireshark "% Malformed frames"	Re-transmissions of Malformed Frames ~ A/[1/(C-1)]	Lost Frames (= if(A<=3049, 0, 3049-A, 0))	FCS + Lost Frames + Malformed frames (= if(A<=3049, 0, 3049-A, 0))	"True" Malformed Packet	"Traditional" Malformed Packet	Error Rate (= [D+F]/(A+B)) = G/(A+D+F)	Error Rate (= B/(A+D))	% Malformed Packet	Computed Potential ACI/Desired Power Ratio (%)	Computed Potential ACI/Desired Power Ratio (%)
7	11	14	-61	-53	8	3122	0	1.4%	44	73	0	44	1%	0%	1%	1.0%	-20
7	11	14	-61	-52	9	3418	0	6.8%	249	369	0	249	7%	0%	7%	1.3%	-19
7	11	14	-61	-51	10	3325	0	5.4%	190	276	0	190	5%	0%	5%	1.6%	-18
7	11	14	-61	-50	11	3500	0	7.4%	280	451	0	280	7%	0%	7%	2.0%	-17
7	11	14	-61	-49	12	3680	0	10.2%	418	631	0	418	10%	0%	10%	2.5%	-16
7	11	14	-61	-48	13	3600	0	10.2%	409	551	0	409	10%	0%	10%	3.2%	-15
7	11	14	-61	-47	14	3500	3	9.7%	376	451	0	379	10%	0%	10%	4.0%	-14
7	11	14	-61	-46	15	3550	10	12.0%	484	501	0	494	12%	0%	12%	5.1%	-13
7	11	14	-61	-45	16	2500	30	8.7%	238	0	549	817	30%	1%	29%	6.4%	-12
7	11	14	-61	-44	17	2000	39	14.4%	336	0	1049	1424	61%	2%	59%	8.0%	-11
7	11	14	-61	-43	18	2000	80	25.0%	667	0	1049	1796	67%	4%	64%	10.1%	-10
7	11	14	-61	-42	19	2100	20	30.0%	900	0	949	1869	62%	1%	62%	12.7%	-9

Per IEEE Specification, the Adjacent Channel Rejection Limit is reached when the Packet Error Rate reaches 10%. At 22MHz spacing, the ACR limit is between 11-12dB.



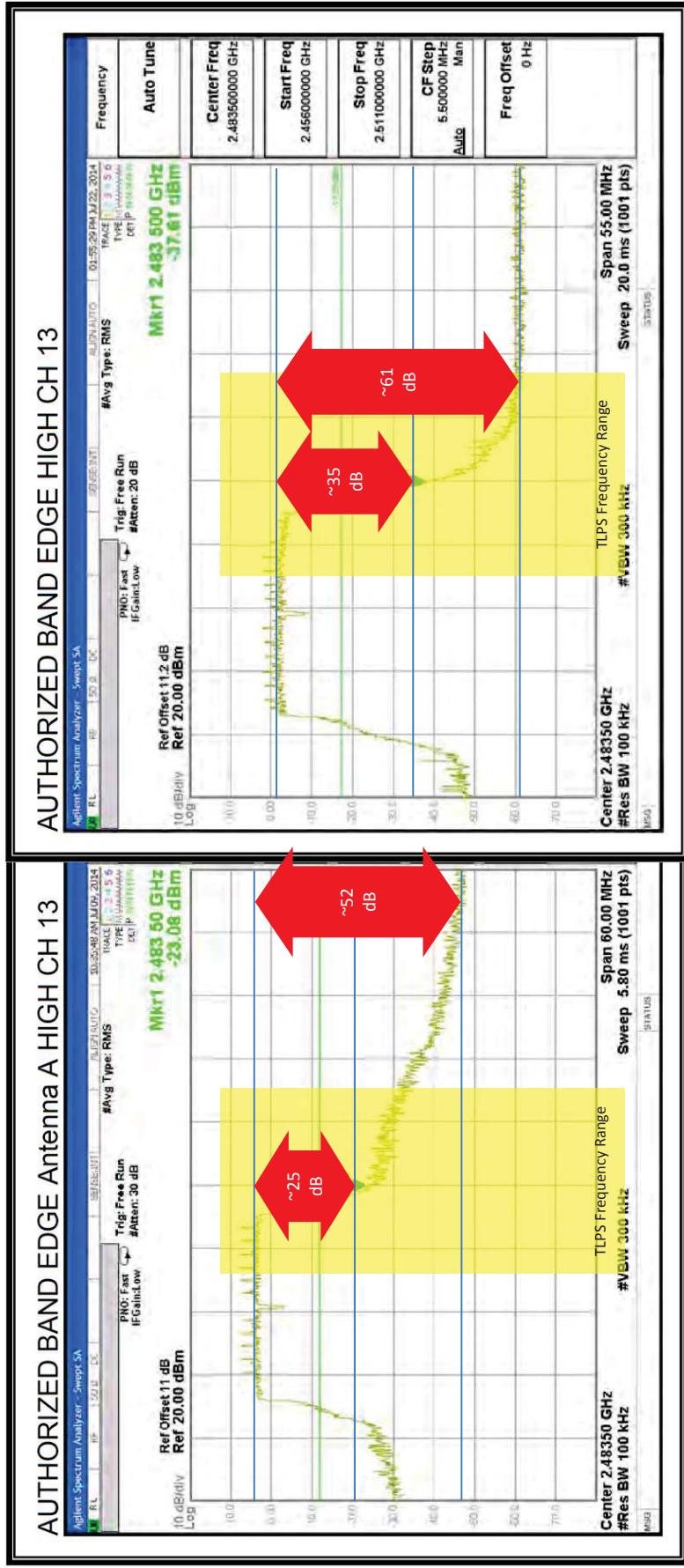
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- 3) Co-existence Filter Removal from Ruckus AP Raises Red Flags
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- 5) Gerst Capital Response to Nprm



COEXISTENCE FILTER EFFECT EXAMPLE: APPLE IPAD AIR 2 CLIENT

From Part 15.247 Test Reports for two versions of the Apple iPad Air 2¹
 iPad Air 2 with WiFi Only (A1566)



“Out-of-channel” profile of LTE-enabled vs. WiFi-only version of iPad Air 2 shows:

- At Center Frequency(2483.5MHz), LTE-enabled Version has ~10dB additional attenuation
- LTE-enabled version reaches the “noise floor” ~8.5MHz above Center Frequency
- WiFi-only version has ~9dB higher “noise floor”, and doesn’t reach this level until ~27MHz above Center Frequency

¹ WiFi-Only Version: See Section 9.3.6, page 86 of report for FCC ID BCGA1566. LTE-Enabled Version: See 9.3.6, page 157 of report for FCC ID BCGA1657.



FCC REPORT IMPLIES TESTING OF “OFF-THE-SHELF” RUCKUS HARDWARE

Language on pages 8 & 9 of Report TR 15-1002 implies Globalstar did not inform the FCC that Ruckus hardware used in March Demonstration was modified from the commercial version that had passed Part 15.247 tests.

1.1 Executive Summary

The primary purpose of this testing was to characterize the electromagnetic emissions profile of sample devices that Globalstar, Inc. (Globalstar) used in a recent demonstration of its proposed terrestrial low power service (TLPS) at the FCC Technology Experience Center.¹ The sample devices provided for these tests were manufactured by Ruckus Wireless and contained modular transmitters approved under Sections 15.247 and 15.407 of the Commission’s rules.² The objective of this testing was to characterize the transmission profile of the devices; there was no intent or effort to perform comprehensive compliance testing.

Table 1 provides a list of the sample devices covered by this test report.

Test Type	Manufacturer	Model	FCC ID	Serial Number
Conducted	Ruckus Wireless	ZoneFlex 7982 AP	S9G-MPE2N33A, S9G-MPE5N33A	141403003812
Radiated	Ruckus Wireless	ZoneFlex 7982 AP	S9G-MPE2N33A, S9G-MPE5N33A	471473600229

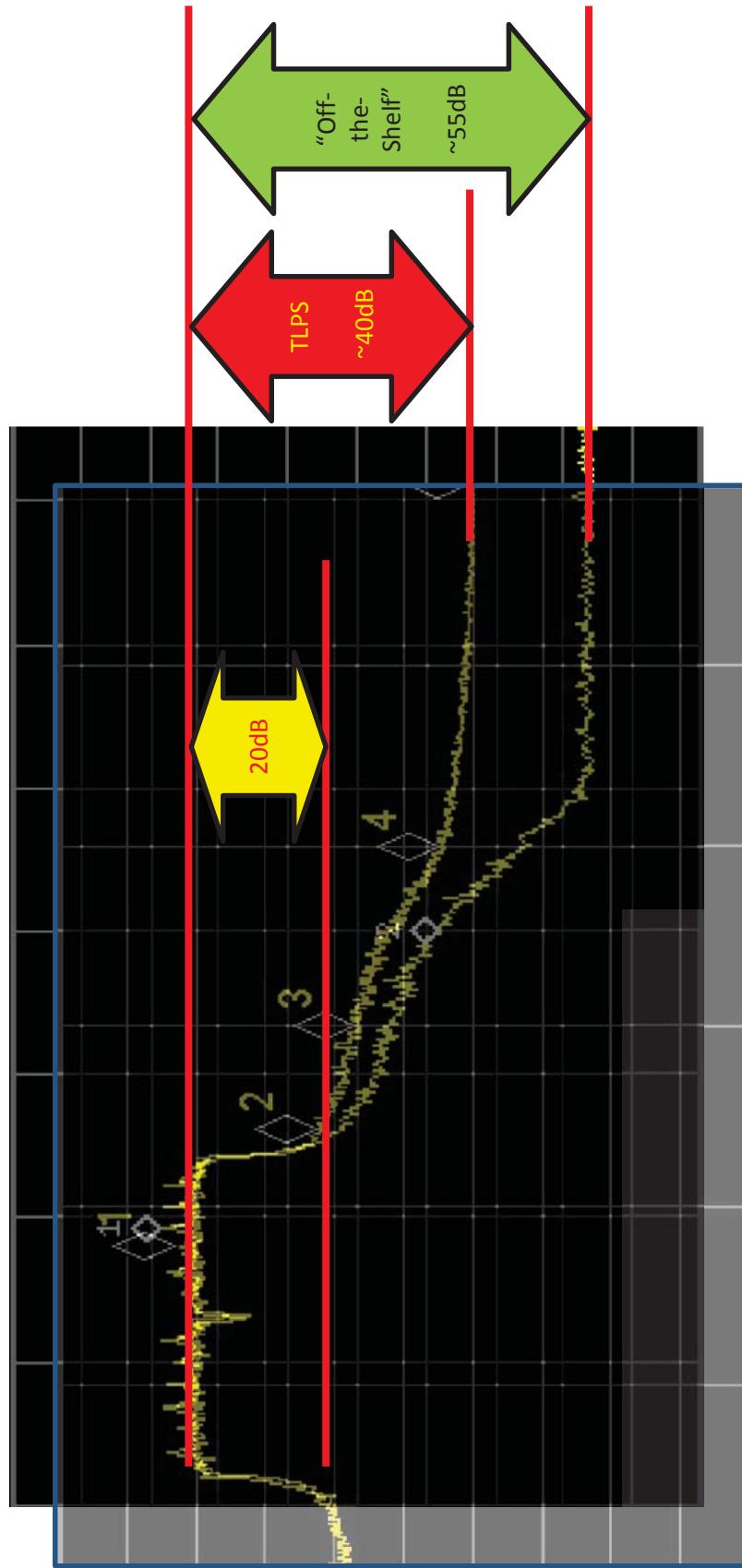
Table 1 – Sample Device List (EUT)



COMPARATIVE ANALYSIS OF EMISSIONS DATA SHOWS TLPS HARDWARE WAS MODIFIED

Overlay & align emissions mask for Channel 11 from Part 15.247 & Channel 14 from TR 15-1002 with frequency and power axes to scale¹.

“Off-the-Shelf” hardware exhibits >15dB additional out-of-channel attenuation vs. TLPS hardware.

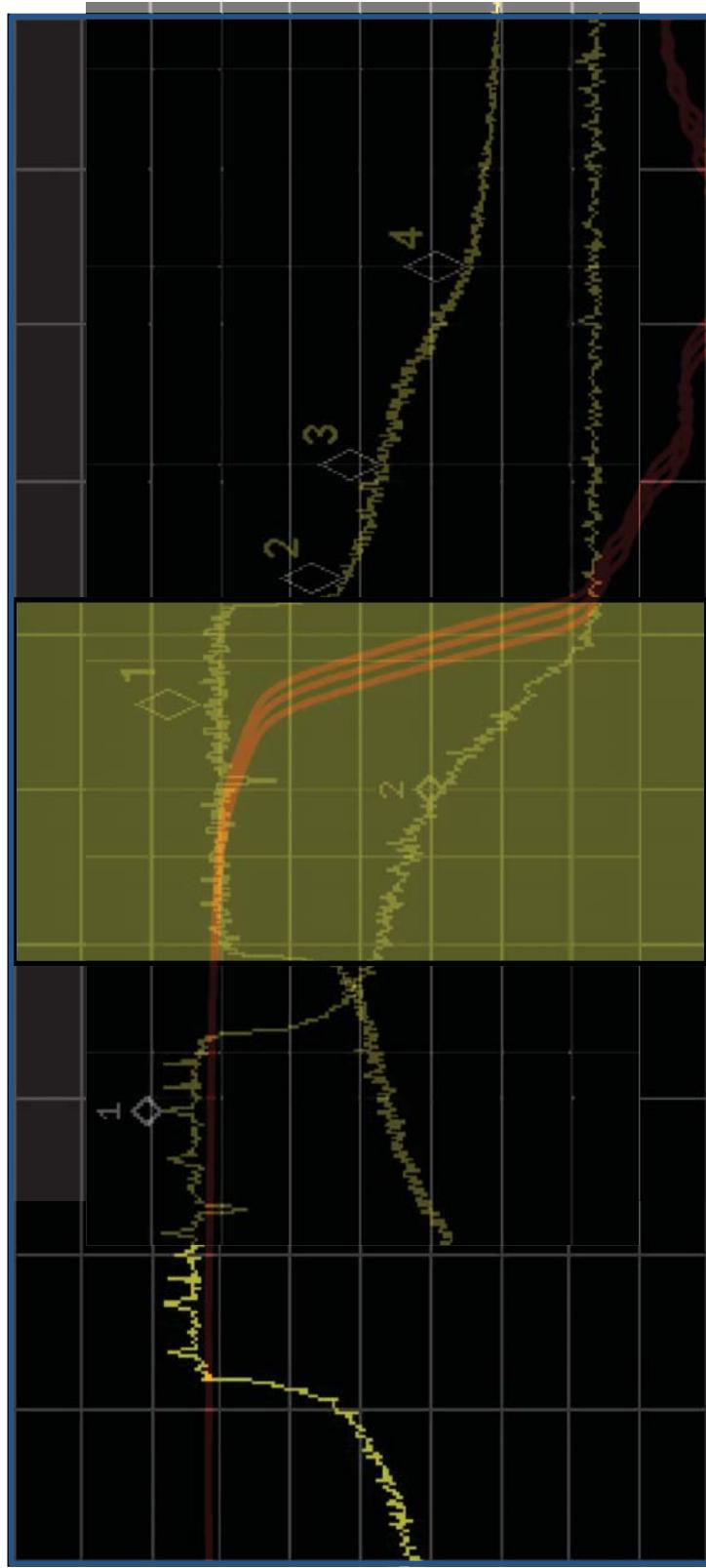


¹Key spectrum analyzer settings are identical (RBW = 100kHz, VBW = 300kHz) in both reports, allowing for comparability after scaling axes.



COMPARATIVE ANALYSIS OF EMISSIONS DATA SHOWS TLPS HARDWARE WAS MODIFIED

Starting with Part 15.247 emissions data, overlay/align TR 15-1002 channel 14 data in frequency and power. Finally, overlay insertion loss profile of two popular coexistence filters (Avago ACPF-7124 & ACFF-1024 insertion loss profile show in RED at high, middle, and low operating temperatures).



Emissions data for “off-the-shelf” Ruckus 7982 clearly indicates the presence of a coexistence filter

Emissions data for Ruckus 7982 hardware used in TLPS demonstrates exhibits NO EFFECT FROM A COEXISTENCE FILTER



AGENDA

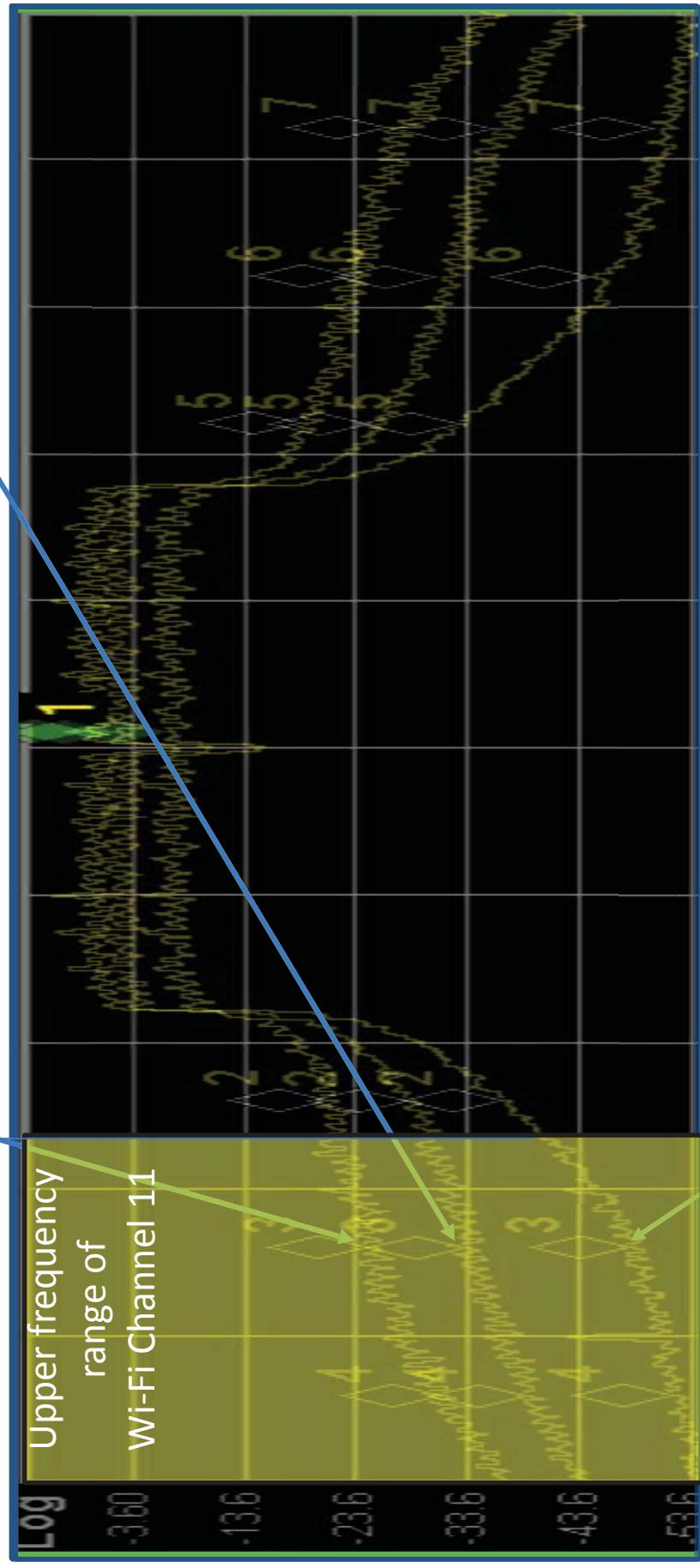
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EACH 1dB TX POWER STEP LEADS TO ~2dB RISE IN ADJACENT CHANNEL INTERFERENCE¹

P0 = +23dBm (Max Power)

P1 = +20dBm (Max Power minus 3dBm)
(Power Level Used by Globalstar in March Demonstration)²

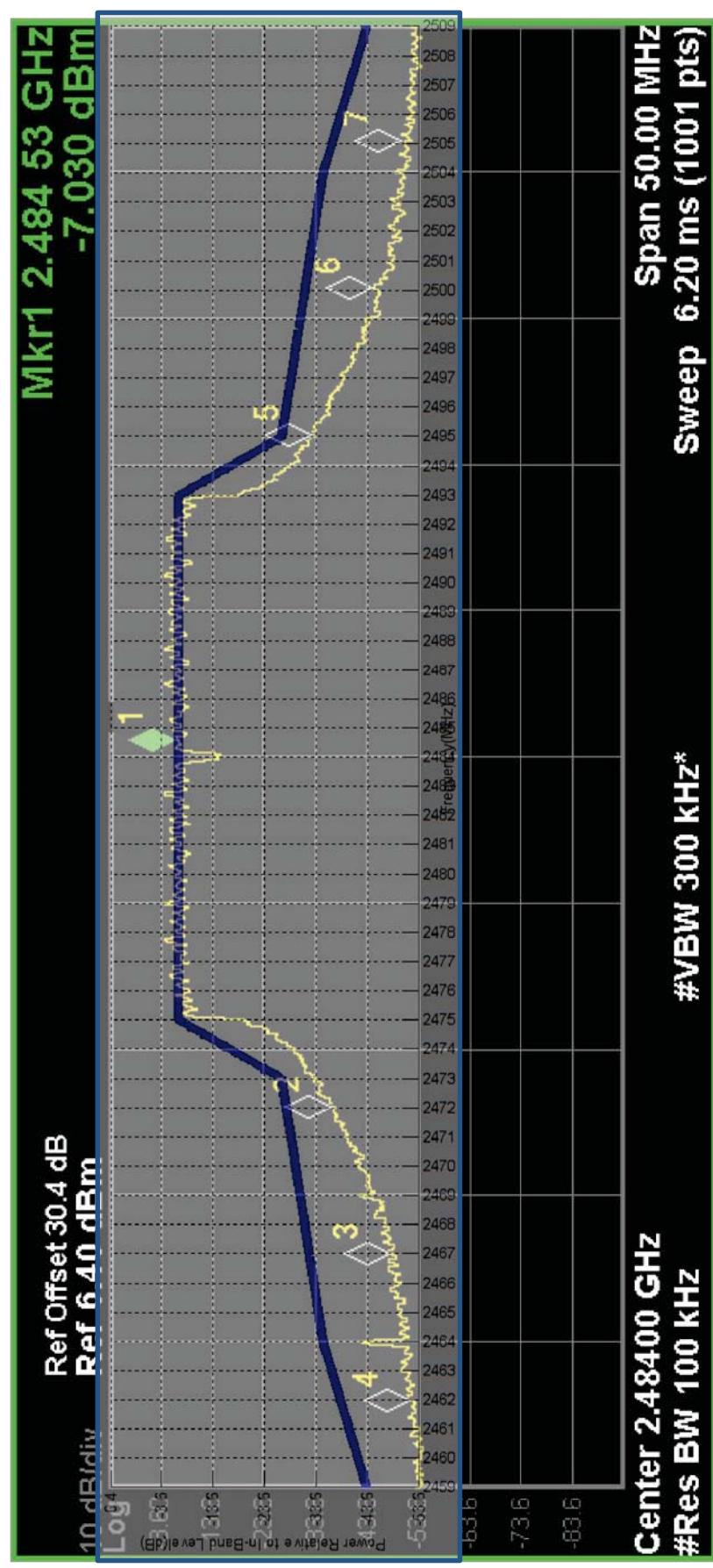


¹Relationship derived from OET Emissions Report data when TIPs AP transmit power is increased from P2>P1>P0. Analysis data is available to FCC staff upon request.

²See FCC OET Staff "Report on Demonstrations of Globalstar, Inc.'s Proposed Terrestrial Low-Power Service March 6-9,2015", IB Docket No. 13-213 (April 1, 2015)



IEEE Emissions Mask Overlay with TLPS AP Power at +15dBm (P2=Max-8dBm)

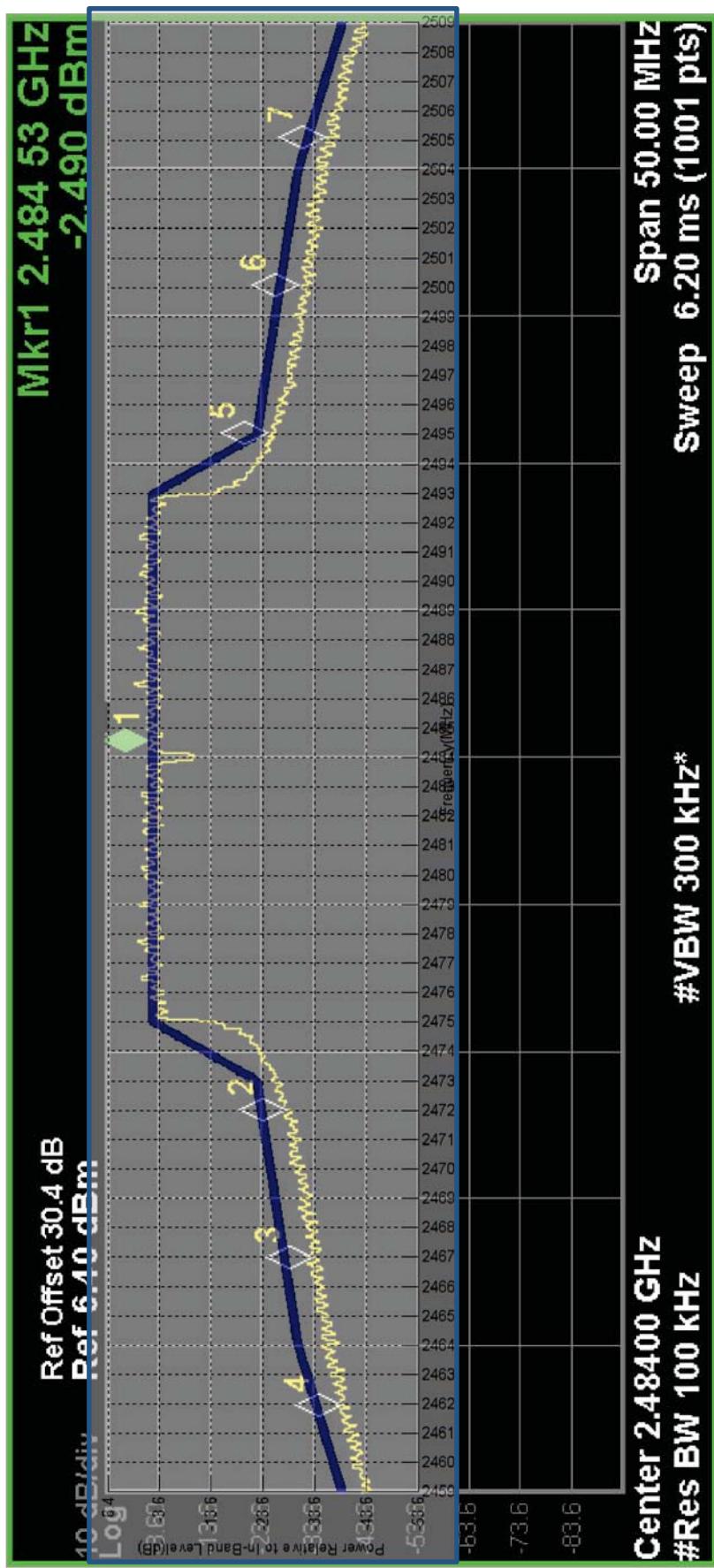


MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	2.484 53 GHz	-7.073 dBm			
2	N	1	f	2.472 00 GHz	-37.226 dBm			
3	N	1	f	2.467 00 GHz	-48.462 dBm			
4	N	1	f	2.462 00 GHz	-52.595 dBm			
5	N	1	f	2.495 00 GHz	-33.247 dBm			
6	N	1	f	2.500 00 GHz	-45.047 dBm			
7	N	1	f	2.505 00 GHz	-50.875 dBm			

Lowest Power (P2) Easily Meets IEEE Emissions Mask



IEEE Emissions Mask Overlay with TLPSS AP Power at +20dBm (P1=Max-3dBm)

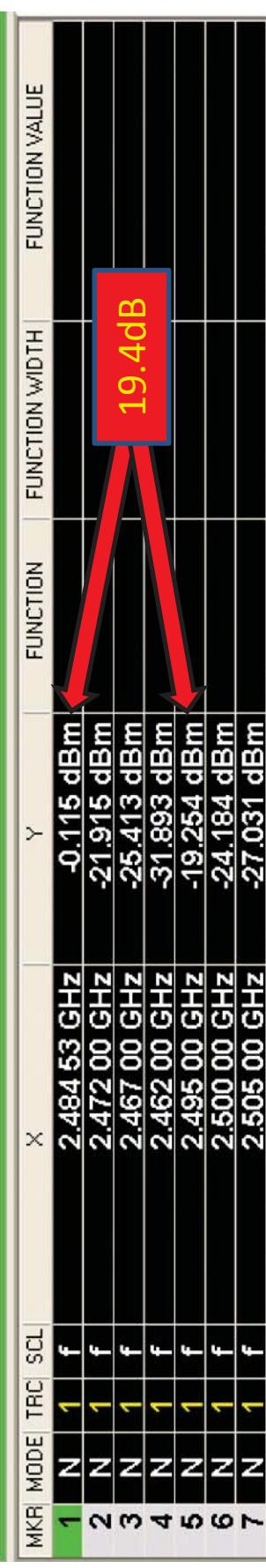
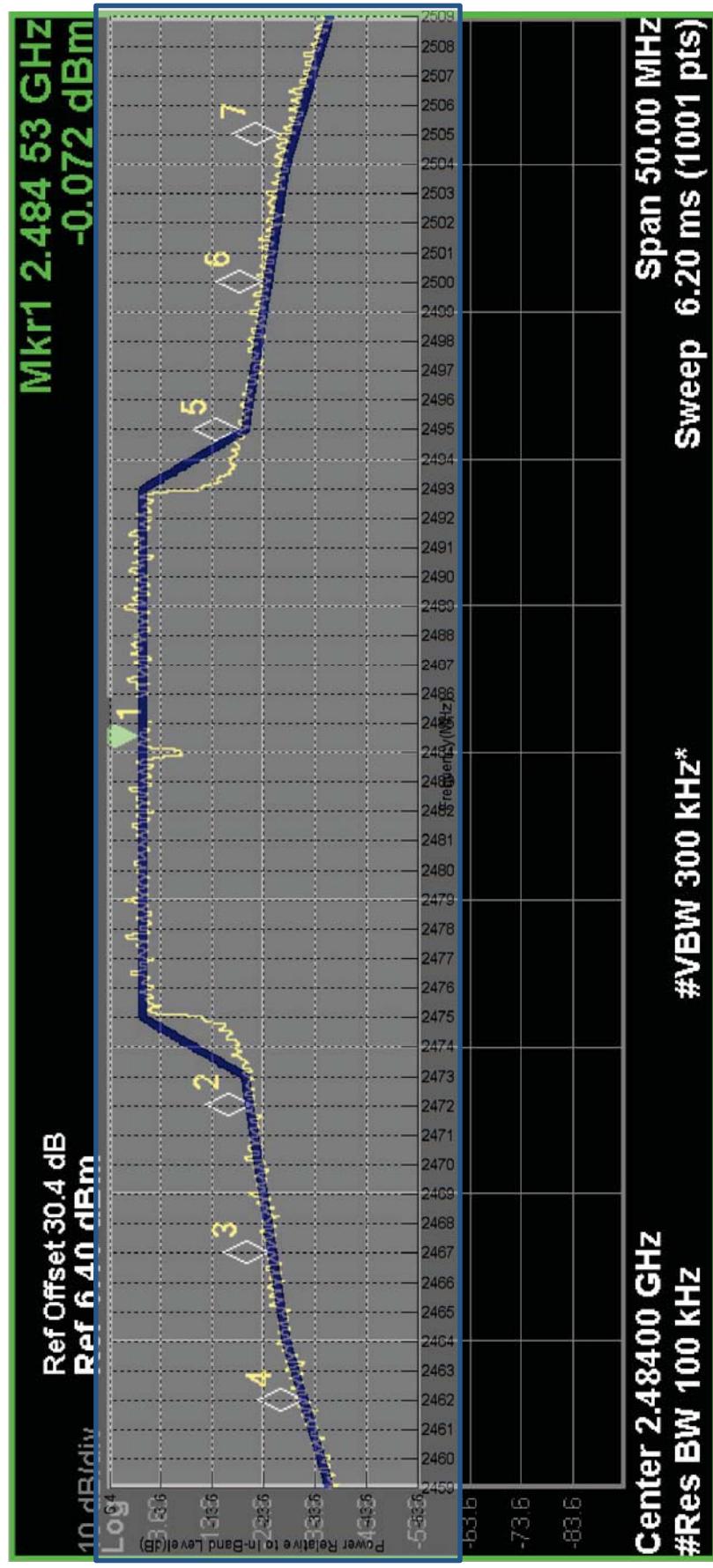


MKR	MODE	TRC	SCL	X	Y	FUNCTION	FUNCTION WIDTH	FUNCTION VALUE
1	N	1	f	2.484 53 GHz	-2.518 dBm			
2	N	1	f	2.472 00 GHz	-28.924 dBm			
3	N	1	f	2.467 00 GHz	-34.013 dBm			
4	N	1	f	2.462 00 GHz	-39.533 dBm			
5	N	1	f	2.495 00 GHz	-25.576 dBm			
6	N	1	f	2.500 00 GHz	-31.437 dBm			
7	N	1	f	2.505 00 GHz	-36.397 dBm			

Middle Power (P1) Level Used in TLPSS Demonstration Just Meets IEEE Mask



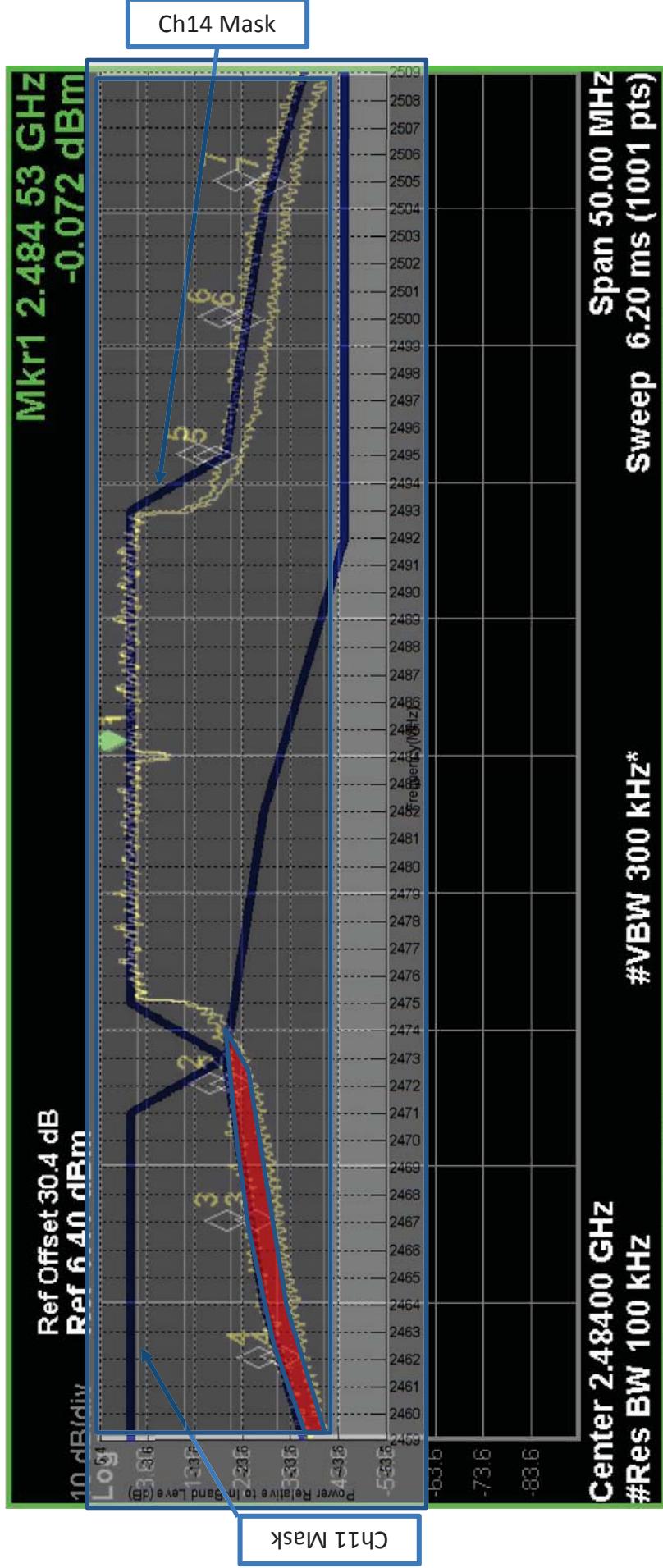
IEEE Emissions Mask Overlay with TLPs AP Power at +23dBm (P0=Max)



Maximum Power (P0) Violates IEEE Mask (at Markers 3, 5, 6, & 7)
If 15.247(d) Measurement Shifts from 2483.5MHz to 2495MHz, TLPs AP Fails 20dB Attenuation



Emissions Mask Overlay with TLPS AP Power at P0(Max Pwr) & P1(March Demo Pwr)



OET Emissions Report Data & Figures illustrate multiple issues:

- Setting the TLPS AP Power to P1 allowed Globalstar to reduce interference by ~6dB in Wi-Fi Channel 11 (red-shaded region). Using 3dB attenuators at antenna ports, Globalstar could have configured TLPS APs at Maximum Power, and still achieved the same effective radiated power seen in the March Demonstration
- Reduced adjacent channel interference levels also favored Globalstar in Bluetooth<>TLPS Tests
- If a high-end, expensive Access Point fails to meet IEEE and FCC¹ Emissions masks operating on TLPS, the FCC can NOT assume other "consumer grade" devices will meet these specs "by design".

¹Paragraph 28 of the NPRM implies the Part 15.247(d) requirement for 20dB attenuation at 2483.5MHz would shift to 2495MHz for TLPS Devices



AGENDA

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- 5) Gerst Capital Response to NPRM



GERST CAPITAL RESPONSE TO NPRM

Response to NPRM:

- Paragraph 1: “..determine whether this proposal has the potential to enable more efficient use of S-band spectrum and spectrum in the adjacent band. This action could potentially increase the amount of spectrum available for broadband access in the United States. At the same time, significant concerns have been raised about potential detrimental impacts on unlicensed devices. We seek comment on the costs and benefits of the proposed approach, and on changes to our rules which may facilitate such deployment and minimize any negative impacts.
 - Response: Information available in this proceeding’s record is not sufficient to enable the commission to approve the proposed rule changes. To the contrary, multiple independent parties have provided the Commission information that demonstrates “detrimental impacts on unlicensed devices”. In the absence of comprehensive system test results demonstrating “peaceful coexistence” between widely used unlicensed services and TLPS, the Commission should terminate this proceeding.
- Paragraph 3: “Channel 14 is unused by IEEE 802.11 devices today in the United States because such devices are not authorized to operate in frequencies above 2483.5 MHz. Globalstar argues that consumers could use their existing Wi-Fi enabled devices with wireless access points Globalstar plans to deploy if restrictions in radiofrequency (RF) software in the current devices are lifted by modifying the devices’ software.
 - Response: Publicly available information cited in this filing and others proves this statement is not true for all devices. The analysis provided to the Commission on 5/14/15 in addition to further information provided in Slides 17-20 proves Globalstar found it necessary to modify commercial hardware used in the March demonstration. Publicly available Part 15.247 test reports for a variety of client devices shows TLPS will, at best, be impaired for the majority of LTE-enabled client devices, and in certain cases (ex: iPhone 6) will not work at all. Ironically, Globalstar currently doesn’t know which LTE-enabled devices will or will not work with TLPS since most “Tier 1” manufacturers do not disclose specifications for proprietary coexistence filters used in their devices. If the data in the Apple iPhone 6 Part 15.247 test report is any indication, it is possible the majority of popular smartphones are not capable of supporting TLPS operation at all. If a decision regarding TLPS rests on the assumption that all, or even the majority, of existing Wi-Fi devices will support unimpaired operation on TLPS via a “software upgrade”, then publicly available evidence indicates the Commission should terminate this proceeding.





Response to NPRM:

- Paragraph 16: “We believe that Globalstar’s proposal to deploy a low-power terrestrial system in the 2473-2495 MHz band should be examined to determine whether it is possible to increase the use of this spectrum terrestrially in the near term, without causing harmful interference to users of this band and adjacent bands, and without compromising Globalstar’s ability to provide substantial service to the public under its existing MSS authorization. ...As a result, these changes may induce increased investment and innovation throughout the industry and ultimately improve competition and consumer choice....We note that significant concerns have been raised about potential detrimental impact on unlicensed devices, such as Bluetooth, that are currently used extensively for various wireless broadband services and applications. We specifically seek further information and supporting detailed technical analysis regarding concerns with any potential detrimental impact on existing unlicensed devices in the 2400-2483.5 MHz band. We also seek comment on the results of testing of Globalstar’s low-power mobile broadband network.”
 - Response 1: Even with the limited testing done to date, the commission has evidence that TLPS will cause harmful interference to existing users of the unlicensed band. It is up to the Commission whether they will request additional technical information from Globalstar and/or opposition parties to gain a better understanding of how much harm TLPS will cause existing unlicensed services. We support the idea that the Commission should “strongly encourage more involvement by neutral and collaborative forums rather than by individual stakeholders”, as suggested by the Hearing Industry Association¹. However, if the Commission does not contemplate such a forum, and/or does not intend to require interested parties to provide information of sufficient depth and breadth necessary to further understand the technical risks posed by TLPS to existing unlicensed devices in the 2400-2483.5MHz band, then this proceeding should be terminated now.
 - Response 2: Contrary to the idea that “these changes may induce increased investment and innovation throughout the industry”, it is conceivable TLPS impairments to Bluetooth (and BLE) and Wi-Fi could have the opposite effect. For example, if TLPS creates widespread quality problems for Bluetooth Low Energy devices, it will hinder/slow down investment in this rapidly growing area.

¹See Letter from Laura A. Stefani, Counsel for The Hearing Industries Association to Marlene H. Dortch, Secretary, FCC, IB Docket 13-213 (July 13, 2015), page 3.

GERST CAPITAL RESPONSE TO NPRM

Response to NPRM:

- Paragraphs 21 & 22: “Globalstar argues that since Bluetooth devices are frequency-hopping systems that operate on constantly varying 1 megahertz channels throughout the 2400-2483.5 MHz band, the 2473-2483.5 MHz band segment represents just one small portion of the unlicensed spectrum that is utilized by Bluetooth technology and its low-power network is no more likely to cause harmful interference to a Bluetooth device than already existing IEEE 802.11-based Wi-Fi operations elsewhere in the 2400-2483.5 MHz band. Globalstar contends that Bluetooth devices and other unlicensed equipment will be able to coexist with its low-power network and continue to operate in the 2473-2483.5 MHz band, **without any loss of spectrum for Bluetooth** and other existing and future unlicensed technologies”
 - Response: Information presented here (Slide 4) and in an earlier filing¹ presents a straightforward analysis illustrating why the addition of TLPs to a high-traffic Wi-Fi environment (i.e.: three “busy” non-overlapping channels) will cause increased interference to Bluetooth and Bluetooth Low Energy devices. Furthermore, the Bluetooth SIG test cited on Slide 3 quantitatively proves the problem is real. If this test were somehow improperly designed or executed, it would be a simple matter for Globalstar to obtain the necessary devices and test equipment to provide a quantitative rebuttal. The combination of a simple analysis and simple tests prove TLPs creates harmful interference for, at least, Bluetooth Low Energy Hearing Aides. We believe this alone is reason enough for the Commission to terminate this proceeding now.

¹See Attachment to Letter from Gerst Capital, LLC to Marlene H. Dortch, Secretary, FCC, IB Docket 13-213 (April 14, 2015) “Analysis of Globalstar’s TLPs Proposal”, Slides 4-10.





Response to NPRM:

- Paragraph 23: “We seek comment on any costs, in terms of impacts on unlicensed operations both in the 2473-2483.5 MHz band and below 2473 MHz (i.e., in the 2400-2473 MHz band) that might flow from Globalstar’s proposed low-power terrestrial network. To the extent that any party asserts that Globalstar’s low-power network may cause interference or substantially constrain other operations, we encourage the party to submit technical analyses detailing their concerns, as well as a detailed assessment of any associated costs.”
 - Response: In regards to Wi-Fi, much of the focus has been on the negative impact on Channel 11, the channel closest to TLPS in the US. However, the information presented on Slides 7 & 8 describes the potential for TLPS to have a negative impact on all Wi-Fi users on all channels in a scenario of co-located TLPS and non-TLPS deployments. We encourage the Commission to solicit input from industry to determine the extent of RRM/SON system usage in Wi-Fi networks, as well as the potential impact if such networks were co-located with a TLPS deployment.

GERST CAPITAL RESPONSE TO NPRM

Response to NPRM:

- Paragraph 28: "... Section 15.247 specifies limits for unlicensed operations by digitally modulated communications equipment operating in the 2400-2483.5 MHz band. We believe it is appropriate to apply the same limits with respect to the 2483.5-2495 MHz band, given the nature of the proposed operations, including the use of digital modulation, and the widespread use of this limit in designing Part 15 devices. We seek comment on this proposal."
 - Response 1: Based on information presented in this filing and others, the Commission can not assume all Wi-Fi devices will support TPLS operation with a simple "software upgrade". If a device requires hardware modification (such as removal of a coexistence filter) to support TPLS, as did the Ruckus 7982 Access Points used in the March Demonstration, existing FCC rules require that device must go through Part 15.247 compliance testing again. Since coexistence filters have a significant impact on a device's emissions profile at the lower and upper portion of the 2400-2483.5Mhz band, removal of this filter may result in the modified devices failing compliance tests they had passed previously.
 - Response 2 : Given the likelihood a material percentage of existing and future Wi-Fi devices will not support TPLS due to the coexistence filter issue (or exhibit unpredictable impairments), it raises the question of whether there will be two distinct compliance test regimes (Part 15.247 and "TPLS-Compliant"). Furthermore, would a "TPLS-Compliant" device also need to pass the full set of 15.247 tests (namely the 2483.5MHz emissions limits while transmitting on Channel 11)?
 - Response 3: This paragraph implies the Part 15.247(d) test that effectively requires 20dB attenuation at 2483.5MHz (relative to the highest level in the desired channel) will be shifted to 2495MHz. Though not intended to be a comprehensive compliance test, information in the OET Emissions report indicates the modified Ruckus 7982 Access Point hardware used in the March demonstration would fail this test¹. If the Commission allows this proceeding to continue, we ask that the commission a) publish the details of a proposed modified set of Part 15.247 tests to be used for TPLS-enabled devices, and b) require Ruckus to submit their TPLS-enabled hardware to an FCC-certified compliance tests lab and publish the test results to this proceeding. Given the single TPLS-capable device with publicly available emissions data appears to fail a critical emissions limit, it seems the Commission should require a test report from at least one client device to ensure "consumer grade" hardware is capable of meeting this difficult emissions requirement. Among others, parties with licensed spectrum starting at 2495MHz would likely have interest in these test results.

¹See report TR 15-1002, "ELECTROMAGNETIC EMISSIONS CHARACTERIZATION OF SAMPLES USED AT TPLS DEMONSTRATION", prepared by the FCC OET (May 7, 2015), Figures 32, 35, 38, 41, 44, and 50. Compute the power difference between Marker 1 and Marker 5.





Response to NPRM:

- Paragraph 29: "...Globalstar further argues that its access points and higher powered terminal devices will be equipped with high selectivity passband filters, which will further segregate Channel 14 operations from those on Channel 11. We seek comment on these concerns and claims."
 - Response: Globalstar has presented no material to backup their claim of "high selectivity passband filters which will further segregate Channel 14" resulting in a benefit to Wi-Fi Channel 11. Information presented in Slides 10-15 presents controlled test results indicating the 22MHz channel spacing between Channels 11 and TLPS results in higher interference than the standard 25MHz non-overlapping channel spacing. The OET Emissions Test report for the modified Ruckus 7982 provides no support there is any additional filtering on the lower edge of Channel 14/TLPS (vs. the upper edge of Channel 14 or either edge of Channel 6). In fact, the only high selectivity bandpass filter (the coexistence filter) was REMOVED for the TLPS-enabled version of the Ruckus Access Point.

Response to NPRM:

- Paragraph 30: “We seek comment on the appropriate limit for unwanted emissions below 2473 MHz resulting from Globalstar’s proposed low-power operations at 2473-2495 MHz. One possible limit is specified in Section 15.247(d) of the Commission’s rules. That rule, applicable to spread spectrum or digital modulation systems operating in the 2400-2483.5 MHz band, specifies that in any 100 kilohertz bandwidth outside the frequency band in which a device is operating, the unwanted emissions shall be at least 20 dB below the fundamental power in the 100 kilohertz bandwidth within the band that contains the highest level of desired power. We recognize that unlicensed use of IEEE 802.11 Channel 11 (2451-2473 MHz) is directly adjacent to Channel 14 (2473-2495 MHz) with no guard band between these two channels, and as pointed out by Globalstar, the overwhelming majority of IEEE 802.11 access points operate on non-overlapping Channels 1, 6, and 11.82 In light of this, we seek comment on whether the current unwanted emissions limit provided in Section 15.247(d) is compatible with systems operating below 2473 MHz from Globalstar’s proposed operations at 2473-2495 MHz. If this limit is not appropriate, we seek comment on an appropriate limit.⁸³ Parties proposing such an emission limit should provide technical analyses and/or studies adequate to demonstrate that their proposed limit is appropriate.
- Response:** Information provided in Slides 10-15 and in earlier filings points to increased interference on Channel 11 in the presence of TLPS. Coming up with an emissions limit that sufficiently protects operations of Wi-Fi Channel 11 while not being overly conservative requires further testing. The current level of testing and analysis is insufficient for any party to technically justify whether the Part 15.247(d) limit of 20dB is sufficient. If possible, the Commission should require “both sides” to come together and devise a comprehensive test plan that would address this issue and many others.





Response to NPRM:

- Paragraph 41: “The Wi-Fi Alliance requests that the Commission consider revising the band-edge restriction and unwanted emissions limits specified in Sections 15.205 and 15.209, respectively, to enable the use of Channels 12 and 13 by Wi-Fi and other unlicensed devices, provided that use does not interfere with Globalstar’s licensed low-power ATC operations in the upper portion of Channel 14, i.e., in the 2483.5-2495 MHz band. Globalstar indicated that it does not object to seeking comment on this issue, but notes that the limits are necessary in order to protect MSS in the 2483.5-2495 MHz band, and that it is fully committed to maintaining that service. Accordingly, we seek comment on this issue. Would relaxation of the limits in order to enable use of Channels 12 and 13 degrade MSS capabilities, particularly if those capabilities are not deployed on the same managed basis as Globalstar contemplates for its operations in Channel 14?”
 - **Response:** In considering this idea, it is important the Commission consider the implications for Bluetooth and Bluetooth Low Energy devices. In making any decision regarding the addition of Channels 12, 13, and/or TLPS, the Commission should consider the impact on the number of “free” Bluetooth channels assuming a maximum number of non-overlapping channels are in moderate-to-heavy use. The analysis provided on Slide 4 shows any combination of three non-overlapping (25MHz spacing) channels spread among Channels 1-13 allows for 22-23 “free” Bluetooth channels. While adding TLPS results in a fourth ‘non-overlapping’ Wi-Fi channel (though spaced at 22MHz, not 25MHz), it reduces the number of “free” Bluetooth channels by 27%. It should also be noted most modern Wi-Fi devices support operation in both the 2.4GHz band as well as the 5GHz band. If we include the (maximum possible) 23 non-overlapping 5GHz channels, Wi-Fi users have a total of 26 channels to choose from. Adding TLPS results in about a 4% capacity addition (as opposed a 33% increase assuming only 2.4GHz). In contrast, Bluetooth can ONLY operate in the 2.4GHz band. Given the current usage patterns, the addition of a fourth “non-overlapping” channel in the form of TLPS results in substantially reduced Bluetooth and Bluetooth Low Energy channels, and as the test cited on Slide 3 shows, impaired performance.



Response to NPRM:

- Paragraph 44: “Globalstar maintains that Wi-Fi enabled devices can be upgraded through software based modification. We seek comment on requiring applicants for certification of certain equipment that operates in the 2483.5-2495 MHz band to provide evidence of Globalstar’s consent to the applicant’s request for equipment certification. Specifically, we propose limiting this requirement to equipment that operates in the 2483.5-2495 MHz band that is used as a network access point and that will operate as a master device as defined in Section 15.202 of the rules, since the master device in a system controls the frequencies on which other devices in the system (client or end user terminal devices) can operate.¹²¹ We therefore do not believe a requirement to obtain Globalstar’s consent is necessary for the certification of devices that operate exclusively as a client to a master device. We seek comment on this approach. Globalstar expects that network access points operating in the 2483.5-2495 MHz band would be new devices. We believe that requiring this additional step would not place a significant burden on the device manufacturers. We seek comment on this proposal.
- Response: Given evidence from publicly available Part 15.247 reports, the OET Emissions report, and analysis of publicly available coexistence filter specifications, it is clear that not all “Wi-Fi enabled devices can be upgraded through software based modification”. Slides 17-20 illustrate that Globalstar even had to modify the Ruckus Access Points used in the March demonstration to allow for unimpaired operation of TLPS. Prior analysis indicates most, if not all, LTE-enabled devices will suffer impairments when attempting to operate on the TLPS channel (with variations in levels of impairment within the same make/model, and even within the same device over the course of a day)¹. Analysis also indicates at least one popular smartphone (iPhone 6) will almost certainly not operate at all on TLPS. We believe the revelation that not all devices will work with TLPS via a “software based modification”, still not publicly acknowledged by Globalstar, has implications for Equipment Certification. We believe the devices should be required to pass a modified set of Part 15.247 compliance tests to assure devices (especially those that required modifications from original Wi-Fi designs) meet emissions requirements both above and below the TLPS range. We request the Commission provide further details in terms of specific modifications to Part 15.247 for TLPS devices.

¹See Attachments to Letter from Gerst Capital, LLC to Marlene H. Dortch, Secretary, FCC, IB Docket 13-213 (March 10, 2015).



Response to NPRM:

- Paragraph 46: “We seek comment on the capability of existing Part 15 devices to be modified through software directly provided by Globalstar to use the 2473-2495 MHz frequency band with the transmission format that Globalstar proposes. In particular, we seek comment on whether the currently deployed devices have the hardware capability to operate in the additional frequency band with the Globalstar proposed protocol. We also seek comment on whether existing devices could be modified though over-the-air software changes, or whether changes to the devices’ firmware would be necessary. We also seek comment on the means that Globalstar plans to use to control the availability of software updates and prevent unauthorized modifications to certified equipment. We seek further comment on how Globalstar will limit operation of equipment to parties that are authorized to use its spectrum, and also how we would ensure that the modified devices would be compliant with the proposed rules.”
 - Response: See prior comments regarding how coexistence filters in LTE-enabled client devices and some access points (such as the commercial version of the Ruckus 7982) will impair, if not prevent, TLPS operation. Given the unknowns created by this situation (variability of impairments within the same make/model, and even within a given device over different temperatures), the only practical solution is that every TLPS-capable device go through a modified version of Part 15.247 compliance tests (plus other tests motioned). If Globalstar proposes TLPS be enabled on any device containing a coexistence filter, tests should account for manufacturing variances and temperature effects on the filter. Based on analysis¹, widely used coexistence filters begin attenuating the signal well within the TLPS frequency range, and due to “temperature motion”, the impact on TLPS operation will vary even within a given device. Combining this with manufacturing variability, it is entirely possible a single sample from a given make/model operates successfully on TLPS and passes all compliance tests. However, if there is not sufficient margin, other samples of that same make/model may exhibit widely varying impairments while on the TLPS channel, ranging from severe distance limitations to non-operation. It seems the Commission will need to take this into account when thinking about consumer protection.

¹See first attachment to Letter from Gerst Capital, LLC to Marlene H. Dortch, Secretary, FCC, IB Docket 13-213 (March 10, 2015), “Even if Approved, Globalstar’s TLPS Will Underperform Free Wi-Fi On [Tens Of] Millions of Existing Devices”.

Response to NPRM:

- Paragraph 47: "...If the client devices can be modified by over-the-air software upgrades by Globalstar, how should such change be classified under our current rules and which party should be held responsible for compliance of the devices?"
 - Response: See response to paragraph 46. Given the uncertainties described earlier, we believe the Commission should require a new grant of certification and a new FCC ID for all TLPS-enabled devices, or at minimum, those known to have coexistence filters.





SUPPORTING MATERIAL

Supporting Links:

- Link to IEEE 802.11-2012 Specification: <https://standards.ieee.org/findstds/standard/802.11-2012.html>
 - Click on "Access via the IEEE Get Program", enter "User Type" and "Email Address" and click "ACCEPT"
- Link containing explanation of different "clause numbers" of 802.12-2012 and changes from 802.11-2007:
<http://blogs.aerohive.com/blog/the-wi-fi-security-blog/why-did-80211-2012-renumber-clauses>
- Links regarding Ixia:
 - <http://ixiacom.com/>
 - <http://www.ixiacom.com/products/ixveriwave>



Technical Papers relevant to Wi-Fi Adjacent Channel Interference Studies:

- Effect of adjacent-channel interference in IEEE 802.11 WLANs (http://upcommons.upc.edu/e-prints/bitstream/2117/1234/1/CrownCom07_Cready.pdf)
 - Describes method for computing ACI in a given desired channel.
 - Also addressed the reduction in “offered throughput” when channels overlap.
 - Conclusions focus on 802.11b. Subsequent research clearly highlights ACI for OFDM-based Wi-Fi is worse than DSSS-based.
- Adjacent Channel Interference in 802.11a: Modeling and Testbed Validation (<http://www.eu-mesh.eu/files/publications/RWS2008.pdf>)
 - Demonstrates the effect of adjacent channel utilization, not only adjacent channel spacing.
 - Effect of channel utilization on interference (whether adjacent or co-channel) is directly relevant to the analysis of “Fact #1: TLPS Will Increase Co-Channel Interference with Bluetooth”, given in the April 14, 2015 Ex Parte presentation. The low channel utilization in Globalstar’s March TLPS demonstration had the effect of lowering interference with adjacent Wi-Fi channels and Bluetooth devices versus higher, more realistic, utilization (i.e. traffic) levels.
- Adjacent Channel Interference in 802.11a is Harmful. Testbed validation of a simple quantification model. (http://www.aueb.gr/users/vsaitis/publications/p16_IEEECommMag_ACI_draft.pdf)
 - Presents a possible improved “cabled RF environment” for further testing.
- Susceptibility of IEEE 802.11n networks to adjacent-channel interference in the 2.4GHz ISM band (<http://pe.org.pl/articles/2012/9b/73.pdf>)
 - Specific to 802.11n networks.
 - Scenario 2 shows material degradation in 802.11n throughput for all channel spacing < 25MHz. Validates full rates only achieved when channels are non-overlapping.
- Diagnosing Wireless Packet Losses in 802.11: Separating Collision from Weak Signal (<http://pages.cs.wisc.edu/~suman/pubs/diagnose.pdf>)



WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE

Test Procedure for 25MHz, 22MHz, & 20MHz Channel Spacing Scenarios:

- 1) Configure “desired” channel on ports TX1/RX1, and “interferer” on ports TX2/RX2. For each channel, configure a single AP/single virtual client transmitting UDP frames from TX->RX at 3049 frames/second, with frame size set to 1518 bytes. This will achieve a “UDP-Level” throughput level of ~37Mbps. Each TX/RX pair will operate at MCS7, giving a PHY channel capacity of 64Mbps, with the associated “UDP-level” capacity being ~63Mbps . The configuration results in both the “desired” and “interferer” channel utilization of approximately 59%.
- 2) Measure desired channel power level at port RX1. Adjust TX1 port power level until RX1 power level is -61dBm, per section 20.3.21.2 of IEEE 802.11-2012 for testing adjacent channel rejection at MCS7.
- 3) Begin transmission of network data on desired channel and verify 0% packet errors.
- 4) Begin increasing TX2 power level in 1dB steps until > 0% packet errors are observed at port RX1. Back off TX2 power by 1dB, configure RX1 port to the “interferer” channel and measure the received power power level. This TX2 power level will be the starting “interferer” power for all subsequent tests, and the difference between the “interferer” channel’s measured power at RX1 and the “desired” channel’s power (-61dB) power at RX1 is the starting “ACI Level”.
- 5) At that “ACI Level”, observe the following key statistics for a period of 30 seconds: “Receive Frame Rate”, “Receive FCS Errored Frame Rate”. Record the observed median value for each.
- 6) At the same ACI Level, begin Wireshark data collection for a period of 10 seconds. Record the “% Malformed Frames” recorded by Wireshark.
- 7) Increase “ACI Level” 1dB by increasing TX2 port power level, repeat steps 5 & 6.
- 8) Collect statistics across “ACI Level” range determined during 25MHz channel spacing test scenario.



WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE



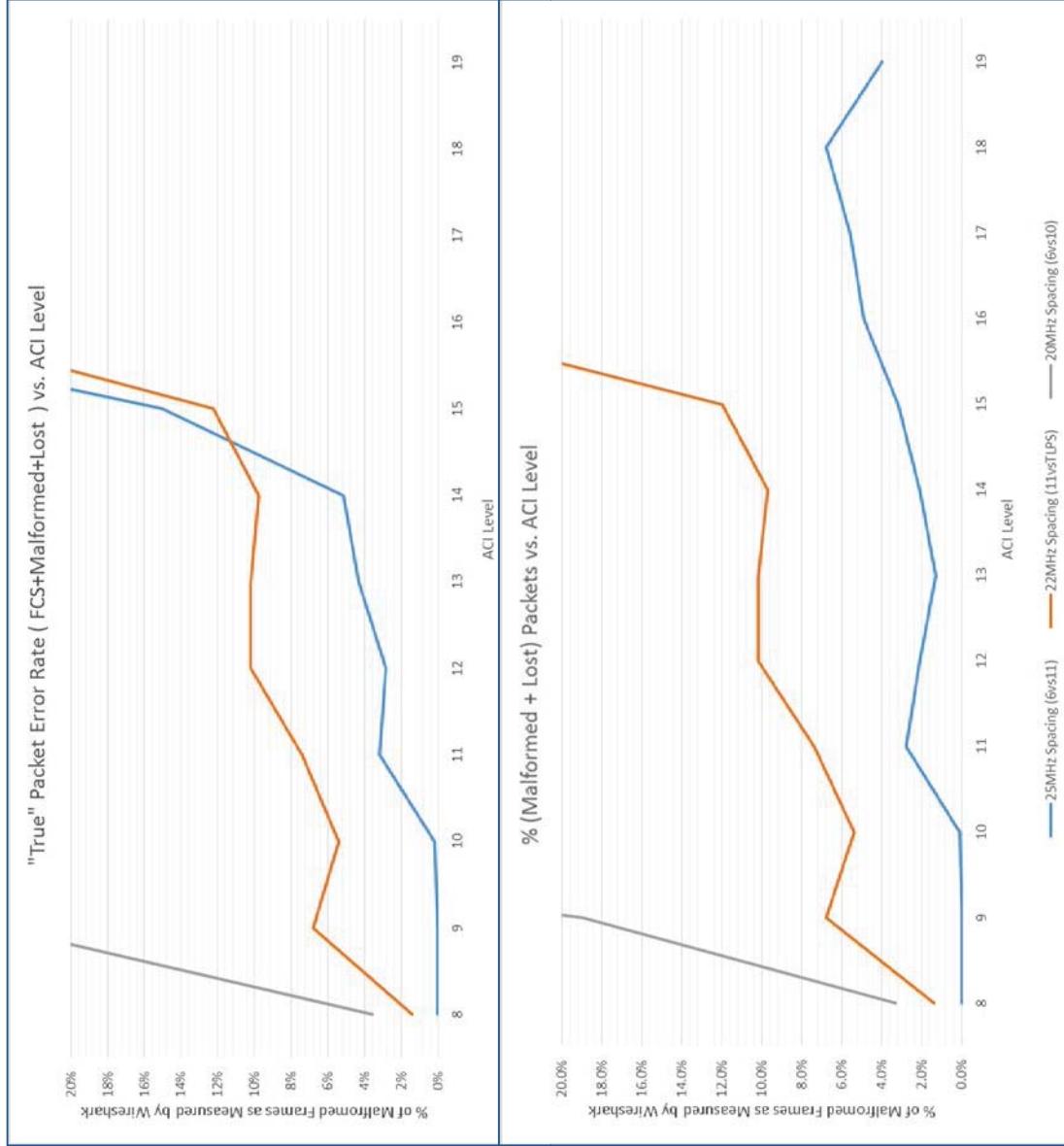
Test Data for 20MHz Channel Spacing (Channel 6 Desired, Channel 10 Adjacent Channel Interferer)

MSC	Desired ACI Level	Desired Channel	Lowest Severity Error		Middle Severity Error		Highest Severity Error		Derived		Derived		Derived	
			Collected	Collected	Collected	Collected	Collected	Collected	Derived	Derived	Derived	Derived	Derived	Derived
			ACI Level (ACI Pwr - Desired Power at Desired Pwr) at RX1 (dBm)	Desired Channel Receive FCS Total	Desired Channel Receive FCS %	Wireshark Malformed "frames"	Re-transmissions ~ = A/[L/C]-1	Lost Frames (= if(A>3049, 3049-A, A-3049, 0))	FCs+Lost Frames + "True" Malformed Packet	"Traditional" Packet	"Malformed" + Lost (= if(A>3049, 3049-A, B+F)/[A+D])	Error Rate (= G/[A+D])	Error Rate (= [B+F]/[A+D])	Malformed
			ACI Channel (dBm)	Frame Rate	Frames									
			A	B	C	D	E	F	G	H	I	J		
7	6	10	-61	-53	8	3000	9	1.7%	52	0	49	110	4%	0%
7	6	10	-61	-52	9	2600	130	2.1%	56	0	449	635	24%	5%
7	6	10	-61	-51	10	2000	70	2.3%	47	0	1049	1166	57%	4%
7	6	10	-61	-50	11	2100	3	2.4%	52	0	949	1004	47%	0%
7	6	10	-61	-49	12	1781	0	2.5%	46	0	1268	1314	72%	0%
7	6	10	-61	-48	13	1700	2	3.2%	56	0	1349	1407	80%	0%
7	6	10	-61	-47	14	2100	80	2.9%	63	0	949	1092	50%	4%
7	6	10	-61	-46	15	2100	1	3.0%	65	0	949	1015	47%	0%
7	6	10	-61	-45	16	1700	2	3.8%	67	0	1349	1418	80%	0%
7	6	10	-61	-44	17	1700	5	4.4%	78	0	1349	1432	81%	0%
7	6	10	-61	-43	18	1700	5	3.4%	60	0	1349	1414	80%	0%
7	6	10	-61	-42	19	1600	10	3.8%	63	0	1449	1522	92%	1%
														91%

WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE



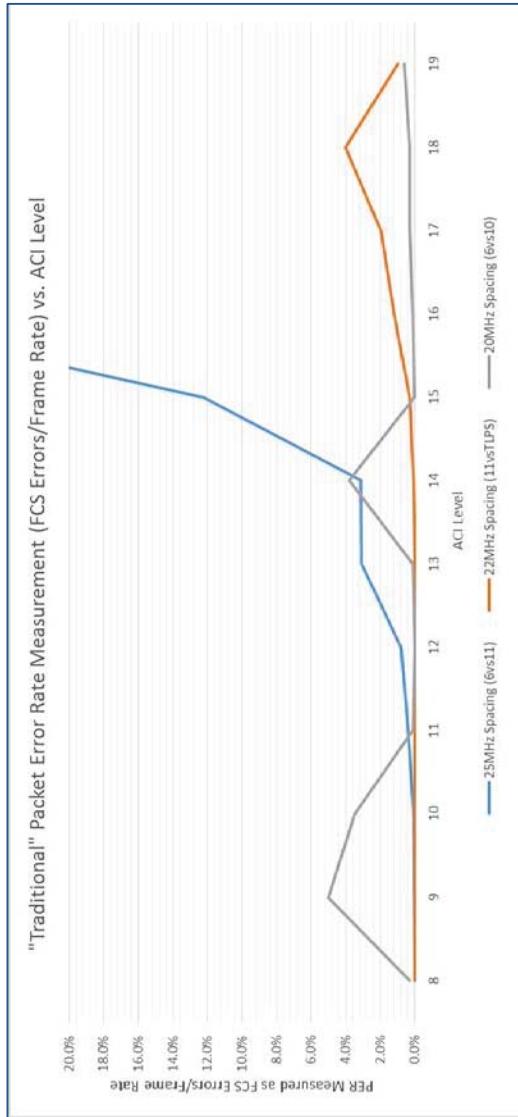
Results Summary and Implications:



WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPs INTERFERENCE

Results illustrate the importance of using the right test equipment

- For our test configuration, the “traditional” method of computing packet error rate showed negligible PER for 22MHz and 20MHz across all ACI levels...clearly not correct.



- Unlike test equipment used by Globalstar to produce their TLPs demonstration, Ixia's IxVeriWave provides access to all PHY and MAC Wi-Fi statistics, allowing for precisely controllable test configurations. Without it, we would achieve inconsistent, unreliable results when trying to quantify the impact of 25MHz vs. 22MHz vs. 20MHz channel spacing.



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Important notes regarding these tests:

- IxVeriWave's RF Hardware meets specifications significantly in excess of those for consumer-grade Wi-Fi equipment.
Whatever ACI effects are observed using IxVeriWave as the emulated client, "real-world" consumer-grade client hardware will perform worse. Without including a representative set of "TLPS-enabled" client devices, it is impossible to know how much worse actual clients will perform with 22MHz channel spacing vs. results collected with the "Ixia-only" testbed.
- Testing was conducted on April 29th and 30th with total time spent configuring the testbed and conducting tests being ~12 hours. While this demonstrates the power and efficiency of using IxVeriWave as the core piece of test equipment, it was not sufficient to perform the breadth of tests necessary for the FCC to assess all technical risks related to the issue.
- Given time constraints, "desired" and "interferer" signals were combined using simple RF splitters/combiners. The passive analog component topology described in the paper "Adjacent Channel Interference in 802.11a: Modeling and Testbed Validation"¹ and/or "Adjacent Channel Interference in 802.11a is Harmful"²(modified for testing in the 2.GHz band) might provide a better "cabled RF environment".
- Collection of "Desired Channel Receiver Total Frame Rate" and "Desired Channel Receive FCS Errored Frames" was done by observing values over a 30-second time period, and picking a median value. This method is obviously susceptible to human entry error, and should be automated.

¹ <http://www.eu-mesh.eu/files/publications/RWS2008.pdf>

² http://www.aueb.gr/users/vsiris/publications/p16_IEEECommMag_ACI_draft.pdf



WI-FI ADJACENT CHANNEL REJECTION TESTS SHOW INCREASED TLPS INTERFERENCE



Important notes regarding these tests (continued):

- Both desired and adjacent channels were configured as a single AP/single client pair simulating a continuous streaming download (e.g.: Netflix scenario). Relative to a multi-client configuration with the same aggregate throughput, this was a relatively benign environment. A multi-client configuration would produce far more “overhead” traffic, especially as a rising ACI level causes retransmission requests across all clients.
- Changing from a single client to multi-client environment requires only a software change in IxVeriWave. The existing hardware configuration would remain the same.

With a representative set of TLPS-enabled clients and Bluetooth devices, Ixia test equipment could be used to execute comprehensive testing that would quantify virtually all key technical risks associated with Globalstar's TLPS Proposal. Based on our experience, such testing could be designed and executed in a matter of weeks.